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A new North American Endophyllum*

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(WITH PLATE 2 AND TWO TEXT FIGURES)

The genus *Endophyllum*, of which *E. Sempervivi* is the type and the best known example, is distinctive in that its spores, to all outward appearances aeciospores, being accompanied by intercalary cells and a peridium and borne in an Aecidium-like fructification, are in reality true teliospores that give rise to promycelia and basidiospores on germination, as Hoffman† and others have conclusively demonstrated. *Gymnoconia*, thought to be an aecial form until the recent notable work of Kunkel‡ on *G. interstitialis*, is to be considered an allied genus, in which the teliospores have intercalary cells but are not enclosed in a peridium. In both cases the vegetative mycelium is perennial in the tissues of the hosts and the life histories are completed with the production of a single spore form, the teliospore, in addition to the basidiospores and pycniospores.

During the past summer we have succeeded in demonstrating the *Endophyllum* character of *Aecidium tuberculatum* Ellis & Kellerm., a rust of the western prairies and uplands on malvaceous plants, especially *Callirhoë involucrata*.

The *Callirhoë* rust has been an object of investigation by the

* Read before the Botanical Society of America at the Philadelphia meeting, December 29, 1914.

† Hoffman, A. W. H. Centralbl. f. Bakt. 2 Abt. **32**: 137–158. 1912.

‡ Kunkel, L. O. Bull. Torrey Club **40**: 351–366. *pl. 3*. 1913. Am. Jour. Bot. 1: 37–47. 1914.

[The BULLETIN for January (**42**: 1–54. *pl. 1*) was issued January 29, 1915.]

botanical department of the Purdue Experiment Station for the past ten years and during a considerable part of this period infected plants of *Callirhoë involucrata* have been grown in the experimental garden at Lafayette. The probable *Endophyllum* character of the form was recognized at the first from certain features in the structure of the sorus, the perennial mycelium, and the failure of field studies to disclose any likely alternate stage. In order to test this assumption it was necessary to have material near at hand for germination and infection studies and Mr. E. Bartholomew of Stockton, Kansas, very kindly sent infected *Callirhoë* plants for this purpose. The first consignment of these plants was received in 1904 and they were subsequently grown in the garden three or four years, producing aecia each year. Germination tests of the spores made by the senior writer in 1907 disclosed only non-septate germ tubes (TEXT FIG. 1) and the conclusion was reached

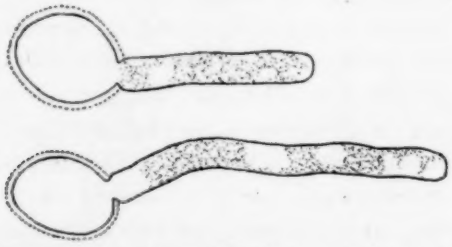

FIG. 1. Teliospores of *Aecidium tuberculatum* germinated in a Van Tieghem cell. After a drawing by F. D. Kern in 1907.

that the spores were true aeciospores and the structure an aecium in spite of the inferential evidence to the contrary. We now know that the method of germination commonly employed in such tests, the hanging drop of the Van Tieghem cell, was responsible for the failure to discover the true character of the germination.

Early in the present year of 1914 Mr. Bartholomew sent another shipment of infected plants of *Callirhoë involucrata* and germination tests were again instituted. The method of germination employed by Kunkel, sowing on the surface of a non-nutrient agar, was used with complete success. Promycelia and basidiospores were produced in abundance in the first test and in the score or more of subsequent tests that were made, proving conclusively that the spores are in reality teliospores.

With these results in mind a search was made for other aecia on malvaceous hosts that might be of a similar nature. An unnamed species of *Aecidium* on *Sidalcea* and *Althaea*, hitherto considered distinct from *Aecidium tuberculatum*, proved to be so similar morphologically that the identity of the two seemed most probable. The *Sidalcea* form had been tentatively connected with a grass rust, *Puccinia Deschampsiae*, from field studies in Colorado by Mr. E. Bethel, that were afterward inspected by Dr. F. D. Kern and the senior writer in company with Mr. Bethel. Mr. Bethel's field attempts to prove this connection, made at Eldora and Denver, Colorado, and reported to us, had, however, been unsuccessful. At our request, Mr. Bethel sent us, last September, plants of *Sidalcea candida* infected with the *Aecidium* in question. These spores on germination likewise produced promycelia and basidiospores (FIG. 7) identical with those of *Aecidium tuberculatum*. The identity of the two forms, therefore, seems certain.

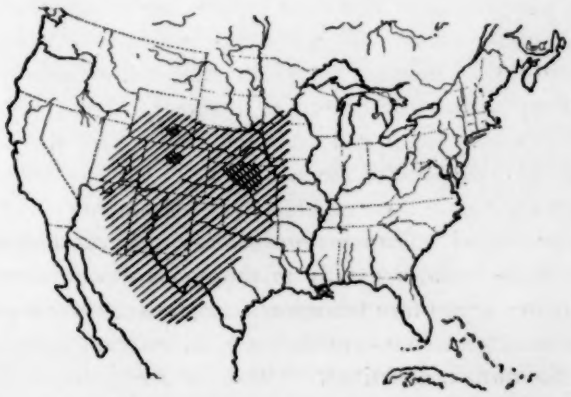

FIG. 2. Distribution of *Aecidium tuberculatum* and its hosts. Diagonal lines indicate approximate distributions of *Callirhoë involucrata*, *Sidalcea candida*, and *S. neo-mexicana;* cross hatching shows areas covering known distribution of *Aecidium tuberculatum*.

The form is known on *Althaea rosea* from the single locality of Red Cloud, Nebraska, where it was collected by the Rev. J. M. Bates in 1910 and where the *Callirhoë* rust is reported as "everywhere." Although we have had no opportunity of testing the germination of its spores there is no real question of its identity with the *Callirhoë* and *Sidalcea* rust.

The type of *Aecidium tuberculatum* was collected by Mr. E. Bartholomew on leaves of *Callirhoë involucrata*, Rooks County, Kansas, September 15, 1887. It has since been found on this host at several stations on the prairies of eastern, central and western Kansas and southern Nebraska. The *Sidalcea* rust is known from several points in the mountains of central Colorado and from a single collection in south central Wyoming (TEXT FIG. 2).

The infection of the various hosts through the sowing of basidiospores has not so far been demonstrated but experiments are under way the results of which should be apparent next spring.

Pycnia are apparently obsolete in this species; a careful search of infected leaves and a study of microtome sections brought forth no traces of them.

The teliospores are normally one-celled, but occasional two-celled spores are produced and one or more of them may be found in any mount (FIG. 2). Their wall thickness, coloring and verrucose sculpturing is like that of the one-celled spores, from which they differ only in form and the presence of a horizontal median septum. They are found in microtome sections of the sori scattered among the one-celled spores in the upper part of the spore chains. Each cell contains two nuclei the products of the conjugate division of the two nuclei of the one-celled spores from which they arise by a vegetative development.

These two-celled teliospores of *Aecidium tuberculatum* are suggestive of those found normally in the genus *Pucciniosira*, which has catenulate, uniseptate teliospores accompanied by a peridium and borne in a cupulate telium that is to all external appearances a true, but diminutive, aecidium. The other morphological features of the sorus and spores of *Aec. tuberculatum*, especially the large, bullate sorus, the fragile, slightly differentiated peridium, and the breaking apart of the spore chains in older sori giving the impression that the spores are compacted without order are, however, characteristic of the genus *Endophyllum* to which it is, therefore, now referred.

Endophyllum tuberculatum (Ellis & Kellerm.) comb. nov.

Aecidium tuberculatum Ellis & Kellerm. Jour. Myc. 4: 26. 1888.

O. Pycnia unknown, probably not formed.

III. Telia aecidioid, hypophyllous and caulicolous, diffused, from a perennial mycelium, following the veins or covering large areas, round or elliptical, bullate, large, 0.5–1 mm. broad by 0.5–1.5 mm. long, yellowish or orange when fresh; peridium colorless, opening at first by a small apical pore, soon disappearing; peridial cells oblong, slightly larger than the teliospores, the outer wall smooth, transversely striate, 5–7 μ thick, the inner coarsely verrucose, thinner, 1–3 μ; teliospores angularly globoid or oblong, occasionally with a transverse, median septum, 16–26 by 18–30 μ; wall pale yellow, moderately thin, 1–2 μ, closely and rather prominently verrucose.

On *Althaea rosea* L.: Nebraska (Red Cloud, October 6, 1910, *Bates*).

On *Callirhoë involucrata* (T. & G.) A. Gray: Kansas (Rockport, now called Stockton, May 20, 1889 in Kellerm. & Swingle, Kan. Fungi *30*, May 22, 1894, Stockton, May 25, 1911 in Barth. N. Am. Ured. *302*, Rooks County, September 15, 1887, May 25, 1897 in Sydow, Ured. *1199*, June 2, 1902, Manhattan, May 1893 in Carleton, Ured. Am. *31*, all by *Bartholomew;* Osborne County, June 1891, *Brown;* Osborne, May 1894 in Rab.-Wint.-Paz. Fungi Eur. 4239, *Shear;* Decatur County, June 1892, *Hitchcock;* Wichita, June 7, 1893, *Carleton*); Nebraska (Red Cloud, May 2, 1903, May 9, 1903, May 14, 1911 in Barth. N. Am. Ured. *601*, *Bates*).

On *Sidalcea candida* A. Gray: Colorado (Eldorado Springs, August 19, 1909, Eldora, September, 1910, Lake Eldora, August 7, 1910, September 17, 1910, August 25, 1911, Tolland, October 29, 1910, September 20, 1914, all by *Bethel*; Routt County, July 16, 1894, *Crandall*).

On *Sidalcea neo-mexicana* A. Gray (*S. malvaeflora* Coulter in Bot. Rocky Mt. Region, not A. Gray): Colorado (Sulphur Springs, November 1910, August 14, 1910, *Bethel*); Wyoming (Seminole Mts., Carbon County, July 23, 1898, *E. & A. Nelson*).

Type collected in Rooks County, Kansas, on leaves of *Callirhoë involucrata, E. Bartholomew 25* (September 15, 1887).

DISTRIBUTION: from eastern Kansas and southern Nebraska to north central Colorado and southern Wyoming.

The germination stages of the teliospores of *End. tuberculatum* are similar to those described by Kunkel for *Gym. interstitialis* and by Hoffman for *End. Sempervivi*. The promycelium is formed at one end of the ellipsoid spore and usually attains its full length,

about 90 μ, before the septa appear. The promycelium is divided, as a rule, into four uninucleate basidiospore initial cells and a basal stalk (FIGS. 6–12). Each basidiospore initial cell gives rise to an ellipsoid basidiospore on a sterigma (FIGS. 7–9). Under suitable conditions the basidiospore germinates at maturity with a slender germ tube that may issue from the apex (FIGS. 6, 8) or from the base near the attachment of the sterigma (FIG. 9).

The common practice of germinating rust spores in the inverted drop of the Van Tieghem cell is undoubtedly the reason why the true character of the very common and much studied *Gym. interstitialis* remained obscure for so many years and Kunkel's discovery is attributable to the important departure in method of germination that he employed.

The production of basidiospores is dependent to a considerable degree on the exposure of the promycelium to a free air surface. If the teliospores are floated on an upright drop of tap water on a slide placed in a damp chamber basidiospores are freely formed, but if sown in an inverted drop of water in a Van Tieghem cell no basidiospores are produced and spore germination may be totally inhibited. A drop of a five percent non-nutrient gelatin may be substituted for the upright drop of water to secure greater stability. If spores are available in large quantities they may be dusted on the surface of water or non-nutrient gelatin or agar in a petri-dish. On a moderately hard agar the basidisopore initial cells produce germ tubes directly without the formation of basidiospores (FIGS. 10–13).

That the moisture and air relations under which teliospores are germinated have a marked effect on the character of their germination has also been shown by Klebahn,* who worked with teliospores of *Puccinia malvacearum*. He found that normal promycelia and basidiospores were produced if the spores were in contact with air and not surrounded by a film of water, but if surrounded by water with the air shut out only long thin tubes were formed.

There is perhaps no basis on which species with aecidioid telia can be distinguished from the aecia of long-cycle forms except in the behavior of their spores on germination. A perennial

* Klebahn, H. Zeitsch. f. Pfl. kr. **24**: 1–32. 1914.

mycelium is no doubt a constant corollary and necessity for all such short-cycle rusts that depend on a non-resting teliospore for propagation in temperate or arctic regions. It is probable that other species, now placed in the form genus *Aecidium* and considered unconnected aecial stages of heteroecious rusts, will prove to be short-cycle forms like *Endophyllum tuberculatum*. Suitable germination tests of such species will decide the matter.

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Explanation of plate 1

ENDOPHYLLUM TUBERCULATUM (Ellis & Kellerm.) Arthur & Fromme

All figures drawn with the camera lucida at an approximate magnification of 625 diameters. FIG. 7 is from *Sidalcea candida*, all others from *Callirhoë involucrata*.

FIG. 1. A one-celled spore showing two nuclei.

FIG. 2. A two-celled spore.

FIG. 3. A peridial cell.

FIGS. 4, 5. Early germination stages of one-celled spores.

FIGS. 6–9. Later germination stages with septate promycelia producing basidiospores.

FIGS. 10–13. Promycelia the cells of which have produced germ tubes.

FIG. 14. A germinating two-celled spore; one of the cells has produced a promycelium.

Pollen development and degeneration in Zebrina pendula, with special reference to the chromosomes

ROBERT T. HANCE

(WITH PLATES 3–5)

The following work on the cultivated wandering Jew, *Zebrina pendula* Schniz., a plant which does not set seeds, was begun with the intention of studying any differences which might exist between the germinal and somatic chromosomes. So many interesting variations in the development of the pollen were found that the present paper is confined almost entirely to a description of these peculiarities.

The chief points developed in the following article are:

1. Parasynapsis occurs, which may readily be followed through the heterotypic divisions.

2. There is no fusion of chromosomes in the heterotypic division. The chromosomes appear in distinctly separated pairs. There are presumably one half as many pairs as there are somatic chromosomes and each pair behaves as a single chromosome—splitting transversely at division. Each daughter cell, therefore, receives as many *pairs* as the mother cell possessed though of one half the size.

3. The number of pairs varies from twelve to fifteen.

4. Chromosomes having the appearance, at first sight, of heterochromosomes appear, but further study shows that any chromosome may behave as such.

5. Entire chromosomes and fragments of chromosomes may be omitted from the reformed nucleus in either the heterotypic or homotypic divisions.

6. The pollen grains grow to a large size, the nucleus may or may not divide, and the cell then vacuolates and goes to pieces leaving only the outer coat shriveled and cracked.

7. Such somatic mitoses that have been observed show a long slender chromosome, whereas the germinal cells possess a short broad chromosome.

It gives me great pleasure to gratefully acknowledge the many valuable suggestions offered by Professor H. M. Benedict during the progress of my work.

MATERIAL AND METHODS

The cultivated wandering Jew was selected because of the ease with which it can be raised in the house and because it flowers steadily through the winter months.

Weak and strong Flemming's solution, equal parts of glacial acetic and absolute alcohol, and Gilson's killing agents were used and the strong solution of Flemming was found to be by far the most satisfactory. The material remained in the fixing fluid from six to twelve hours, and was washed in running water for a similar length of time.

As *Zebrina pendula* produces at various intervals from eight to twelve or more flowers at one point numerous stages may be found in a single piece of material.

Iron alum haematoxylin proved excellent but by far the best results were obtained with safranin counterstained with light green. The chromosomes are very large and when stained with safranin stand out with a sharpness that makes counting and drawing simple. The slides were allowed to remain from two and one half to three hours in safranin and from two to three seconds in light green followed by absolute alcohol, clove oil fifteen minutes, xylol three to four minutes and mounted in balsam or euparal. The latter was found to be excellent for the quickness with which it hardened and the clearness of the finished slide. Sections were cut 10 μ thick though 15 or 20 μ would be better owing to the size of the cells.

Most of the figures were drawn from the safranin preparations.

DEVELOPMENT AND DEGENERATION OF THE POLLEN

Heterotypic Division

Prophase.—The earliest stage observed is pictured in FIG. 1. The nucleus is composed of a dense network and two nucleoli stand out sharply. One is larger than the other and each is surrounded by a clear area. The growth period that ensues is figured in the next few drawings. In FIGS. 2 and 3 the cytoplasm has apparently grown away from the nucleus. This may be an

artefact, though it has been observed a number of times. In FIG. 2 the smaller nucleolus is seen to have lost a great deal of its staining capacity and is moving to the outer edge of the nucleus. It undoubtedly degenerates as only the one large nucleolus is found in succeeding stages.

As the spireme begins to form, the chromatin appears in long threads which completely fill the cavity shown in FIG. 3. The nucleolus stains less deeply but is still very distinct (FIG. 4).

FIGS. 4–7 show various steps in synapsis. FIG. 5 shows the cell developed to its maximum size. The chromatin threads of FIG. 4 have grown to form thick chromatin bands. No foundation has been found, after careful measurement of many different stages of synapsis, for the theory that synapsis is due to a growth of the cytoplasm away from the nucleus. The nucleolus is shown in FIGS. 6 and 7 (*N*). FIG. 7 shows the nucleolus beginning to vacuolate, a process which always seems to precede its disappearance.

As the chromatin bands come out of synapsis it is plainly evident that they are paired—FIG. 8. In FIG. 9, in which the paired bands are already splitting transversely to form the chromosomes, the paired nature is still more plainly visible.

Metaphase.—In the polar views of the metaphase of the pollen mother cells the chromosomes always appear in pairs. In counting great care was taken to secure uncut cells. In a few cases certain single chromosomes were counted as a pair when no other chromosome could be found near it which might be considered its mate. It was believed that its mate was probably covered by itself. With this method of counting FIG. 10 shows thirteen pairs of chromosomes, FIG. 11, thirteen pairs, FIGS. 12 and 13, twelve pairs each. FIG. 18, which, if we judge from the size of the chromosomes and their position, is the early anaphase of the heterotypic division shows fourteen pairs of chromosomes and FIG. 14, which is a similar stage, has fifteen pairs.

In FIG. 15 the two chromosomes "*X*" have all the appearances of heterochromosomes, but FIGS. 16 and 17 show that any chromosome or chromosomes may behave in a peculiar way. In FIG. 16 we find an "odd" body (*X* and *Y*) going to each pole ahead of the other chromosomes while FIG. 17 shows a pair trailing after the

others. It is safe then, I think, to conclude that no odd chromosomes occur in *Zebrina pendula* and that any chromosome may act in a manner not unlike that of the well-known accessory chromosomes.

Anaphase.—Judging from the size and position (i. e., at one end of the cell) of the chromosomes, FIGS. 14, 18, and 19 are anaphases. The paired arrangement of the chromosomes is still apparent and it is evident that the pairs are just one half the size of those in the mother cells. They have resulted from a transverse division of the chromosome pairs and in FIG. 10 the early indication of a transverse split is shown at *A* and *B*. Owing to the size of the cells it is practically impossible to find an uncut cell showing both ends of the anaphase in the same section, but FIG. 20 is a drawing carefully built up from two sections. The dark dotted line in the figure merely indicates the line of separation between the two groups of chromosomes and does not appear on the slide. 27 chromosomes appear at each pole and though the paired arrangement is not so apparent as in the preceding figures, it can still be seen in a few cases.

The dividing wall formed after the heterotypic division is pictured in FIGS. 21–23. In the first two drawings chromatic fragments are figured which trail after the other chromosomes and which probably will fail to reach the reforming nucleus in time to be included. Two entire chromosomes have been omitted from the nucleus in FIG. 23.

Homotypic Division

No dividing cells of this stage which permitted a count of the chromosomes have been found. The period of rest between the heterotypic and homotypic divisions is not very long. As in the case of the previous division, chromosomes may fail to reach the nuclei of the tetrads as shown in FIG. 25. FIG. 26 is a drawing of a complete tetrad.

The Pollen Cell

Each member of the tetrad undergoes enormous growth resulting in the pollen grains pictured in FIGS. 29 and 30. The nucleus may divide once but no later stage has ever been observed.

The cytoplasm becomes vacuolated and finally disappears entirely, leaving the cracked and shriveled outer coat, FIG. 27. Many anthers have been found filled with these empty coats.

SOMATIC MITOSIS

A single drawing of the typical somatic mitosis has been included with the others, FIG. 28. It can readily be seen that the chromosomes are strikingly different from those figured in the other drawings.

DISCUSSION

The above work is of interest in comparing the development of the pollen in normal seed producing plants with that of a plant that has lost its power of setting seeds. It is impossible to say at present whether or not the non-production of seeds is due to the irregularities appearing in the chromosome behavior. Farmer and Shove (2) consider that the varying number of chromosomes in *Tradescantia virginica* may be due "possibly to the common failure of the plant to set seeds." They, too, have recorded cases of chromatic fragments and chromosomes being omitted from the reformed nucleus and claim that they degenerate and are lost in the cytoplasm.

The question of synapsis will not be discussed here for, although I am inclined to the view of parasynapsis from the stages observed, the evidence is not sufficient as yet to base definite conclusions on. Overton (9) gives an excellent bibliography covering this question and the general field of cytology. In *Tradescantia* and *Galtonia*, Mottier (8) holds that "there is in many cells a marked tendency for some of the segments to adhere end-to-end, forming chain-like rows of sausage or kidney-shaped pieces." The peculiar conditions, however, existing in synapsis and reduction in the heterotypic divisions of *Zebrina pendula* suggest once more the question raised by Atkinson (1) as to whether, among plants, there "are not different types of chromosome reduction."

The lack of fusion between the individuals of the chromosome pairs in the heterotypic division may point to a hybrid origin. Gates (3) has cited conditions somewhat similar in hybrid *Oeno-*

theras which were sterile and has reviewed a number of other cases (4). The two germ plasms of Guyer's hybrid pigeons were found to remain separate in the cells of the testes. Speaking of a large chromosome appearing on the spindle as four small rings or vesicles, he says: "It is possible that this indicates a demarcation into tetrads, visible in hybrid material because of the firmer fusion which occurs normally at this stage is lacking. . . . It simply means, that in all probability there is an incompatibility between the chromosomes from the two different species which, in some cases, prevents them from uniting for the pseudo-reduction that normally occurs at this time." He also finds that "the division may be such that a portion of the chromatin is cut out entirely and is left behind in the cytoplasm." (5.)

Miyaki (6) states that the reduced number of chromosomes in *T. virginica* is twelve while Farmer and Shove claim the number to vary between twelve and sixteen. In the present study the number has been found to range between twelve and fifteen.

Mottier (7) states that the chromosomes of *Tradescantia virginica* are arranged in pairs and that in the first division they may be attached end to end so that as they are drawn apart rings may be formed. Each half that goes to the poles soon appears to be paired and remains in that condition until the second division, when the members of the pair separate. This differs from the case reported in the present article in that the pairs in *Zebrina pendula* behave as single chromosomes right through the first division and no evidence of a second longitudinal division has been observed.

The great difference between somatic and germinal chromosomes would seem to point to the fact that chromosomes are influenced by the chemistry of the cell. The writer has observed a difference in the chromosome number of the somatic and germ cells of the pig and in another paper has discussed the importance of chromosomes in heredity from this point of view.

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Explanation of plates 3–5

The drawings were made at table level with the aid of a Leitz camera lucida and using a Zeiss 2 mm. apochromatic objective and a No. 12 ocular. FIG. 27 is the one exception, being drawn under a 3 mm. objective and a No. 6 ocular. Drawn to the same scale as the other figures it would be about as large as FIGS. 29 and 30. The drawings are reduced one third.

SYMBOLS. *N*, large nucleolus. *X* and *Y*, "odd" chromosomes. *n*, small nucleolus. *A* and *B*, chromosomes showing preliminary split.

FIGS. 1–9. *Prophase of Heterotypic Division*

FIG. 1. Two nucleoli appear staining equally.

FIG. 2. Cytoplasm has grown away from nucleus. Smaller nucleolus has lost some of its staining capacity and has moved to one edge of the nucleus.

FIG. 3. Smaller nucleolus has been cast out of nucleus.

FIG. 4. Nucleus has spread to fill the cavity shown in FIG. 3. Chromatin network is beginning to form. Only one nucleolus is present.

FIG. 5. Beginning of synapsis.

FIG. 6. Later stage of synapsis showing nucleolus.

FIG. 7. Later stage of synapsis showing nucleolus beginning to vacuolate.

FIG. 8. The chromatin mass has opened up preparatory to dividing into chromosomes. The parallel arrangement of chromatin bands is apparent.

FIG. 9. Chromatin bands constricting to form the individual pairs of chromosomes. The paired arrangement is marked.

FIGS. 10–17. *Metaphase of Heterotypic Division*

FIG. 10. Polar view showing 13 pairs of chromosomes.

FIG. 11. Polar view showing 13 pairs of chromosomes.

FIG. 12. Polar view showing 12 pairs of chromosomes.

FIG. 13. Polar view showing 12 pairs of chromosomes.

FIG. 15. Side view of spindle showing what are apparently "odd" chromosomes (*X*).

FIG. 16. Same as 15 showing an odd body going to each pole (*X* and *Y*).

FIG. 17. Early anaphase showing a pair of chromosomes trailing after the others.

FIGS. 14–23. *Anaphase of Heterotypic Division*

FIG. 14. 15 pairs of chromosomes appear.

FIG. 18. 14 pairs of chromosomes appear.

FIG. 19. 13 pairs of chromosomes appear.

FIG. 20. A drawing built up from two sections. 27 individual chromosomes can be counted as the pairing is not so obvious. The dotted line does not appear on the slide.

FIGS. 21, 22, 23. Division completed showing reformed nuclei with chromatic fragments and whole chromosomes omitted.

FIGS. 24–26. *Homotypic Divisions*

FIGS. 24, 25, 26. Stages in the formation of tetrad. FIG. 25 shows a chromosome omitted from the reformed nucleus.

FIGS. 27–30. *Miscellaneous*

FIG. 27. Shows the empty and broken pollen covering.

FIG. 28. Somatic mitosis, drawn from a dividing cell in a young sepal.

FIG. 29. Mature pollen, a single nucleus appears and the cell is beginning to vacuolate.

FIG. 30. Mature pollen. Two nuclei are shown.

Mosses of Bermuda

ELIZABETH G. BRITTON

(WITH PLATES 6 AND 7)

There has been no list of the mosses of Bermuda published since 1885,* when William Mitten studied the collections made by the Challenger Expedition and enumerated five genera and eight species, of which two were described as new. One of these, *Trichostomum bermudanum* Mitt., has proved to be endemic and two others, *Tortula melanocarpa* Mitt. and *Isopterygium tenerum* Mitt., have been referred to older names. No localities were recorded.

A taxonomic study of the flora of Bermuda was undertaken by the New York Botanical Garden in 1905† in cooperation with the Academy of Natural Sciences of Philadelphia, and several visits have been made by Mr. Stewardson Brown and Dr. and Mrs. N. L. Britton at various times of the year in pursuit of this investigation. These have yielded twenty genera and twenty-eight species of mosses and added another endemic species, *Campylopus bermudianus*. It will thus be seen that the island is not rich in mosses and the most widely distributed species is *Trichostomum bermudanum* which occurs rather commonly on stone walls and limestone rocks, particularly in shady moist places. A few of the rarer species are likely to become extinct with the clearing, burning and cultivation of the marshes, notably the species of *Sphagnum*, *Campylopus*, *Syrrhopodon* and *Isopterygium;* a few others are only to be found in a few deep dark crevices and caves in the parish of Hamilton. Besides the two endemic species, there are eight cosmopolitan ones belonging to the five genera *Bryum*, *Eucladium*, *Funaria*, *Hymenostylium*, and

* Voyage of H. M. S. Challenger, pp. 89–92. 1885.

† Bermuda in September, Jour. N. Y. Bot Gard. 6: 153–158. 1905; Botanical Exploration in Bermuda, Jour. N. Y. Bot. Gard. 13: 189–194. 1912; Gardens of Bermuda, Jour. N. Y. Bot. Gard. 14: 172. 1913; Jour. N. Y. Bot. Gard. 15: 148. 1914.

Weisia; six having a wide range in temperate North America, Europe and Asia, belonging to the genera *Amblystegium*, *Anomodon*, *Isopterygium*, *Leucobryum*, and *Sphagnum;* and ten species of subtropical or tropical distribution: most of these are not known to occur except in America and represent the eight genera *Cyclodictyon*, *Fissidens*, *Gyroweisia*, *Rhacopilum*, *Sematophyllum*, *Syrrhopodon*, *Thuidium*, and *Tortula*.

Dr. Evans has listed* twenty genera and twenty-two species of the Hepaticae and has since reported two species of *Anthoceros*,† thus bringing the total number of bryophytes to forty-one genera and fifty-two species, the number being almost equally divided between hepatics and mosses. None of the Hepaticae are endemic.

In the following enumeration, unless otherwise stated, the specimens cited by number were collected by Mr. Stewardson Brown or Dr. and Mrs. N. L. Britton; a few were collected by Dr. M. A. Howe in July, 1900.

1. SPHAGNUM MAGELLANICUM Brid.

Sphagnum medium Limpr. Not *Sphagnum cymbifolium* Ehrh., as listed by the Challenger Expedition.

Devonshire Marsh, *M. A. Howe.*

2. SPHAGNUM CUSPIDATUM SERRATUM Schliep.

Sphagnum trinitense C. Müll.

Devonshire Marsh, *M. A. Howe;* Pembroke Marsh, *340*, *417*.

3. CAMPYLOPUS BERMUDIANUS R. S. Williams.

On damp ground in shade of palmetto, Paget Marsh, *651*, *1138*, *1872*.

4. LEUCOBRYUM GLAUCUM (L.) Schimp.

Devonshire Marsh, *M. A. Howe 376;* Paget Marsh, on the ground under shade of palmetto, *1860*.

5. FISSIDENS GARBERI Lesq. & James.

On rocks near Harrington House, *548a;* gully, Abbot's Cliff, *893*, *951*, *1859*.

* Bull. Torrey Club **33**: 129–135. *pl. 6.* 1906.

† Brylogist **13**: 36. 1910; **16**: 55. 1913.

6. FISSIDENS MINUTULUS Sull.

Calcareous rocks, gully near Tuckerstown, *322;* on stones in shade, Church Cave; also on Abbot's Cliff, mixed with *893* and *951*.

7. FISSIDENS TAXIFOLIUS (L.) Hedw.

On the ground in woods near Walsingham Caves, *M. A. Howe*, also *284*.

8. SYRRHOPODON FLORIDANUS Sull. (PLATE 6.)

On base of palmetto in dense mats, sterile; propagating by gemmae from the tips of the leaves. Devonshire Marsh, *M.A. Howe;* Paget Marsh *233, 655, 656, 1856*.

9. WEISIA VIRIDULA (L.) Hedw.

Castle Harbor, Walsingham, *430a*.

10. WEISIA LONGISETA Lesq. & James.

Near Harrington House, *432;* on rocks, Walsingham, *485;* near Tuckerstown, *501*.

11. GYROWEISIA BARBULA (Schwaegr.) Par.

Tortula melanocarpa Mitt. (Challenger Report.)

On rocks near Tuckerstown, *502;* roadside rocks near Paynter's Vale, *517;* also near Harrington House, *549*.

12. EUCLADIUM VERTICILLATUM (L.) Br. & Sch.

Tortula verticillata Mitt. (Challenger Report.)

Wet limestone rocks, Smuggler's Cave, *M. A. Howe;* Church Cave, *271;* walls of Cooper's Hole, Paynter's Vale.

13. HYMENOSTYLIUM CURVIROSTRE (Ehrh.) Lindb.

Under dripping limestone rocks forming calcareous tufa, Church Cave; Walsingham Cave, *1193*.

14. TRICHOSTOMUM BERMUDANUM Mitt.

"In extensive patches on calcareous sand" without locality, Challenger Expedition; on stone wall, Hamilton, *M. A. Howe;* rocks, north shore, *62;* Devonshire Marsh, *97;* rocks and stone walls near Harrington House, *442a, 833;* Paget Sand Hills, *620;* on the ground, Paynter's Vale, *805, 808;* Hall's Island, Harrington Sound, *894;* Abbot's Cliff, *926;* St. David's Island, *1064, 2082;* Montrose, *2214*.

15. TORTULA AGRARIA (Sw.) Sw.

On calcareous rocks near Paynter's Vale, *466;* also near Harrington House, *548.*

16. FUNARIA HYGROMETRICA (L.) Sibth.

On rocks near Harrington House, *551.*

17. FUNARIA FLAVICANS Michx.

Without definite station, *Mrs. W. E. Damon,* 1888.

18. BRYUM DICHOTOMUM Hedw.

Without definite station, Challenger Expedition.

19. BRYUM CAPILLARE L.

Fruiting plants were collected on rocks near Paynter's Vale, *465;* sterile specimens, propagating by gemmae, were found in Paget Marsh, *227;* gully in Abbot's Cliff, *928;* on the side of a cistern, the Flats, *A. B. Hervey,* 1913.

20. BRYUM CRUEGERI Hampe.

Sterile specimens, on stones, Devonshire Marsh, *160.*

21. CYCLODICTYON VARIANS (Sull.) Broth.

On damp rocks in shade, Walsingham Cave, *283;* Church Cave, *801, 1089.*

22. RHACOPILUM TOMENTOSUM (Sw.) Brid. (PLATE 7.)

Without definite station, Challenger Expedition; shaded rocks, fruiting, gully and cave, Paynter's Vale, *326;* Church Cave, *503, 507, 510, 1091;* Gully near Tuckerstown, *515;* Abbot's Cliff, *892, 1857.*

23. ANOMODON ROSTRATUS (Hedw.) Schimp.

A lax sterile form of this species has been found on shaded rocks at a cave near Harrington House, *558,* at Paynter's Vale, *806,* and on Abbot's Cliff, *1877.*

24. HAPLOCLADIUM MICROPHYLLUM (Sw.) Broth.

On shaded rocks, Abbot's Cliff, *890, 925, 926;* Church Cave, *1092.*

25. THUIDIUM MINUTULUM (Hedw.) Br. & Sch.

In gully, Paynter's Vale, *361.*

26. AMBLYSTEGIUM VARIUM (Hedw.) Lindb.

Damp rocks, Church Cave, fruiting, *509*, *804*, *1093;* shaded rocks, Paynter's Vale, *806* in part.

27. ISOPTERYGIUM MICANS (Sw.) Mitt.

Isopterygium tenerum Mitt. (Challenger Report.)

On root-stocks of *Osmunda cinnamomea*, and on old stumps, Devonshire Marsh, *44*, *568*, *809*, *812;* at base of palmetto, Paget Marsh, *647*, *1855;* Pembroke Marsh, *626;* Warwick Marsh, *623*.

28. SEMATOPHYLLUM ADNATUM (Michx.) E. G. Britton.

On cedar tree, Walsingham Cave, *282;* on rotten wood, near cave, Paynter's Vale, *1117*.

Explanation of plates 6, 7

PLATE 6. SYRRHOPODON FLORIDANUS Sull.

Drawings made with a magnification twice the diameter reproduced on the plate.

FIG. 1. Plant, natural size.

FIG. 2. Plant enlarged.

FIG. 3. Cross section of stem, ×120.

FIGS. 4–7. Leaves, ×18½.

FIG. 8. A portion of base of leaf showing curve, ×87½.

FIG. 9. Apex of leaf showing end of costa, ×120.

FIG. 10. The large hyaline cells of basilar portion of leaf, ×500.

FIG. 11. Cells of the basilar and median portions of leaf taken from the upper edge of the hyaline group, represented in Figs. 4, 5, and 7, by dotted lines, ×500.

FIG. 12. Marginal cells, ×500.

FIGS. 13, 14. Median cells, ×500.

FIG. 15, Portion of ventral surface of leaf from costa to margin, ×210.

FIG. 16. Surface view of double margin from median portion of leaf, ×120.

FIGS. 17, 18, 19. Cross sections of double margin, 17, 18, ×270; 19×210.

FIG. 20. Surface view of lower portion of costa, ×120.

FIG. 21. Surface view of upper portion of costa showing papillae, ×120.

FIG. 22. Cross section of lower portion of leaf, ×120.

FIG. 23. Portion of same with higher magnification, ×210.

FIG. 24. Cross section of upper portion of leaf, ×210.

FIGS. 25, 26. Cross sections of costa showing papillae on costa and the cells of the upper portion of leaf, ×210.

FIG. 27. Apex of leaf with gemmae and filaments arising from both the dorsal and ventral surface of costa tip, ×87½.

FIG. 28. Filaments arising from cells of the costa in median portion, ×120.

FIG. 29. Filament arising from a cell of the basilar portion of costa, ×87½.

FIG. 30. Filaments arising from median cells near double margin, ×87½.

FIG. 31. Gemma arising from a median cell, ×87½.

FIGS. 32–34. Gemmae, ×87½.

PLATE 7. RHACOPILUM TOMENTOSUM (Sw.) Brid.

The figures were drawn with a magnification three times greater than that indicated and the resulting figures were reduced to one third.

FIG. 1. Plant, natural size.
FIG. 2. Branch showing arrangement of large and small leaves, ×6⅔.
FIG. 3. Large leaf, ×12⅓.
FIG. 4. Small leaf, ×12⅓.
FIG. 5. Apex of large leaf showing excurrent costa, ×80.
FIG. 6. Basal cells of large leaf, ×80.
FIG. 7. Median cells of large leaf, ×195.
FIG. 8. Surface view showing papillae, ×333⅓.
FIG. 9. Cross section of leaf, ×138⅓.
FIG. 10. Cross section of stem, ×80.
FIG. 11. Perichaetial bud, ×19⅔.
FIG. 12. Capsule, ×4⅔.
FIG. 13. Portion of capsule with lid and calyptra, ×10.
FIG. 14. Peristome, ×80.
FIG. 15. Annulus, ×80.
FIG. 16. Spores, ×80.

A new Hawaiian Cyanea

JOSEPH F. ROCK

(WITH PLATE 8)

The genus *Cyanea* belongs to the family Campanulaceae, subfamily Lobelioideae, and is endemic to the Hawaiian Islands. It contains more species than any other Hawaiian genus of this subfamily, most of the species being arborescent. On the island of Kauai the species are few in number but decidedly distinct. On the islands of Maui and Molokai they are more numerous but also more variable, certain of the species apparently merging into one another. The species described below is named for Mr. G. K. Larrison, superintendent of hydrography.

Cyanea Larrisonii sp. nov.

Stem fleshy, apparently not branching, foliose at the apex, puberulous: leaves linear-lanceolate, acuminate at both ends, minutely mucronate, pale whitish underneath, light green above, glabrous on both surfaces, midrib and veins prominent below, chartaceous, 20–23 cm. long (including a puberulous petiole of 15–18 mm.), 12–20 mm. wide, entire or minutely denticulate in the upper third: raceme 1 cm. long, four- to six-flowered, bibracteate at the middle; bracts 12 mm. × 1 mm.; pedicels 5–6 mm. long; calyx subglobose, dark purplish-black, 5 mm., minutely toothed, tomentulose; corolla slender, 3 cm. long, 3.5–4 mm. wide, dark bluish-black, slightly curved, the dorsal slit extending beyond the middle, tomentose, especially near the apex; staminal column dark purple, glabrous, with a patch of purplish hairs at the base, anthers glabrous, pale, with purplish streaks, the two lower only tufted at the apex; stigma minutely two-lobed, scarcely protruding: berry (immature) globose, purplish-black.

KAUAI: Upper Hanalei Valley, on ridge between Hanalei and Kalihinui, elevation 1,800 feet, October 17, 1914, *G. K. Larrison 10342*. The type specimen is deposited in the College of Hawaii Herbarium.

A very striking species, somewhat related to *Cyanea recta*

Wawra, but differing from it in the linear-lanceolate leaves, which remind one of the leaves of *Rollandia parvifolia* Forbes; the very narrow corolla is almost straight and nearly black.

COLLEGE OF HAWAII,
HONOLULU, HAWAII

Explanation of plate 8

CYANEA LARRISONII Rock

FIG. 1. Part of plant, × 0.6.
FIG. 2. Flower, × 1.4.
FIG. 3. Longitudinal section of flower, × 1.4.

The North American species of Psilogramme*

William R. Maxon

In describing not long ago a new and peculiar species of *Psilogramme* from Porto Rico, it became apparent that the other North American members of the genus (mainly Costa Rican), though treated recently,† were not well understood. Still more recently an apparently undescribed species has been received from Chiapas, extending widely the known continental range of the genus. This has led to a further examination of the entire genus, with particular regard to the North American species. Some of the notes taken are given under the following provisional list of species now reported from North America. The sequence is essentially that of Kuhn's classification.‡

Key to the Species

Veins extending to the emarginate apex of the ultimate divisions.

Fronds erect, obviously determinate; laminae narrow, the primary rachis straight or subflexuous; primary pinnae short, 3 to 8 cm. long.

Rhizome very slender (1 to 2.5 mm. thick), wide-creeping, the fronds 1 to 2.5 cm. apart ..... 1. *P. Warscewiczii.*

Rhizome thick, ascending or decumbent, the fronds fasciculate.

Lamina pale yellowish or grayish green, densely spreading-villose throughout; pinnae rigidly herbaceous, crowded ..... 2. *P. congesta.*

Lamina bright green, laxly glandular-hirsute; pinnae membrano-chartaceous, distant or subdistant ..... 3. *P. chiapensis.*

Fronds very much larger, scandent or recumbent, tardily determinate; lamina ample, the primary rachis widely sinuose-flexuose or strongly divaricate-flexuose; primary pinnae greatly elongate, mostly 12 to 25 cm. long.

Secondary pinnae all very sharply retrorse in attachment but at once curved upward, glabrous throughout; ultimate divisions 1.5 to 2 mm. broad ..... 4. *P. glaberrima.*

Secondary pinnae retrorse only at a broad angle or spread-

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* Published by permission of the Secretary of the Smithsonian Institution.

† Christ in Bull. Herb. Boiss. II. 4: 1096–1099. 1904.

‡ Gruppe Chaetop. 13–22. 1882.

ing, not recurved, variously pubescent; ultimate lobes 1 mm. broad, or mostly much less.
Leaf tissue copiously short-villose upon both surfaces. 5. *P. villosula.*
Leaf tissue scantily pubescent.
Segments minute, the ultimate fertile lobes mostly about 1 mm. long, less than 1 mm. broad, sparsely and laxly pubescent upon both surfaces, or hairs more numerous among the sporangia... 6. *P. haematodes.*
Segments larger, the lobes longer and broader, widely divaricate, glabrous above, bearing a few short hairs beneath among the sporangia... 7. *P. refracta.*
Veins not attaining the margin; teeth of the ultimate segments not emarginate..... 8. *P. portoricensis.*

1. PSILOGRAMME WARSCEWICZII (Mett.) Kuhn, Gruppe Chaetop. 17. 1882.

Gymnogramma Warscewiczii Mett. Ann. Sci. Nat. Bot. V. **2**: 211. 1864.

TYPE LOCALITY: Cartago, Costa Rica (*Warscewicz.*).

DISTRIBUTION: Costa Rica and Colombia, ascending to 3,000 meters.

ILLUSTRATION: Karsten, Fl. Columb. **2**: *pl. 188, f. 3* (as *G. Warscewiczii*).

Psilogramme Warscewiczii was described by Mettenuis upon two collections, one from the Páramo San Fortunato, Colombia, altitude 2,800 meters (*Lindig 299*), the other from Cartago, Costa Rica (*Warscewicz*); the latter must be regarded as the type. The original description, which is very complete, points unmistakably to the common Costa Rican plant redescribed by Christ erroneously as *Gymnogramme hirta* Desv. It is true that *P. hirta* and *P. Warscewiczii* are similar in stature and cut of frond. The former species, however, has the numerous fronds closely fasciculate upon a very short rhizome, and the lamina conspicuously hispid or hirsute with stiff spreading hairs; whereas in *P. Warscewiczii* the fronds are borne singly, an inch or more apart, upon a slender, very widely creeping rhizome, and the lamina is inconspicuously short-villous along the rachises and veins, with lax appressed hairs. The stout stipes and generally sturdy appearance of *P. Warscewiczii* are equally characteristic. Karsten's figure, above cited, agrees well with Costa Rican material and differs only in representing a plant slightly above the maximum of the following specimens examined.

COSTA RICA: Volcán de Poás, altitude 2,300 to 2,644 meters, *J. D. Smith 6930* (3 sheets); *Tonduz 10712; Alfaro 121.* Volcán de Turrialba, alt. 3,000 meters, *Pittier 13256* (*J. D. Smith 7488*).

2. **Psilogramme congesta** (Christ) Maxon.

Gymnogramma congesta Christ, Bull. Herb. Boiss. II. 4: 1098. 1904.

TYPE LOCALITY: Forests of La Palma, Costa Rica, altitude 1459 meters (*Tonduz*).

DISTRIBUTION: Costa Rica, at altitudes of 1,300 to 1,500 meters.

This species has been very well described by Christ. It has the short rhizome, closely fasciculate fronds, and conspicuous spreading hispid covering of true *P. hirta*, but the rigidly erect fronds and sturdy appearance of *P. Warscewiczii*, a species which otherwise it does not closely resemble. The almost grayish, strongly hispid aspect of the plant has been mentioned by Christ. This feature, the close-set pinnae and pinnules of all the fronds, and the peculiarly strict and narrow appearance of the segments of the sterile fronds are the best distinctive marks of this excellent species.

COSTA RICA: Forêts de La Palma, alt. 1,300 to 1,459 meters, *Tonduz 12575; Brade.* La Hondura, near La Palma, alt. 1,500 meters, *Jimenez 594; Werckle 16683.* Without locality, *Werckle* (ex herb. Christ).

3. **Psilogramme chiapensis** Maxon, sp. nov.

Rhizome apparently short, decumbent, freely radicose beneath and at the sides, bearing at the apex numerous dark reddish brown, opaque, rigidly acicular, simple hairs, these 1.2 to 1.8 mm. long, consisting of 10 to 16 cells above the enlarged multicellular base; fronds about 6, fasciculate, 40 to 57 cm. long, erect-arching; stipe 20 to 25 cm. long, 1.3 to 2 mm. in diameter, dark brown from a purplish brown base, lustrous beneath a sparse subpersistent covering of lax multicellular simple brownish hairs; lamina linear-oblong or linear-deltoid to lanceolate, acuminate, 22 to 34 cm. long, 8 to 11 cm. broad, bipinnate-tripinnatisect, the primary rachis similar to the stipe, lightly angled, subflexuous in the apical half; larger primary pinnae about 10 pairs, slightly ascending, the lowermost 2 to 4 pairs opposite or nearly so, these the largest, 5 to 8 cm. long, 2 to 3.5 cm. broad, inequilateral, narrowly deltoid

or triangular-oblong, subacute, subfalcate, fully pinnate in the basal part, the subflexuous secondary rachis elsewhere narrowly foliaceo-marginate, densely clothed with spreading multicellular hairs, these with a darkish terminal gland; pinnules 6 to 10 pairs below the short, cleft or parted apex, mostly spreading, the basal pair slightly the largest or the 3 or 4 basal pairs subequal, regularly pinnatisect to the foliaceous costa, laxly hirsute upon both surfaces, more copiously so beneath, the hairs mostly gland-tipped; segments 2 or 3 pairs below the obtuse usually tripartite apex, mostly oblique, the larger ones inequilateral, obovate or trapeziform from a narrowly cuneate base, obliquely cleft into 2 or 3 lobes, these mostly bilobate at their tips; smaller segments narrower, cuneiform, strongly decurrent, only 2 or 3-lobed; veins very slender, dark brown above, subdichotomous, the 2 to 8 ultimate branches of each segment terminating at the faintly emarginate apices of the lobes; sporangia very numerous, falling short of the tips of the lobes but extending nearly to the base of the segments, the lines widely confluent at maturity. Leaf tissue yellowish green, delicately membrano-chartaceous.

Type in the U. S. National Herbarium, no. 464844, collected upon the Cerro del Boqueron, Chiapas, Mexico, September, 1913, by Dr. C. A. Purpus (*no. 6722*). A second and excellent sheet of three fronds of the same number is at hand; also a later collection from Chiapas (*Purpus 7219*).

Related to *P. hirta* and *P. glandulosa* of South America; differing from the former in its narrower, fewer-veined segments and its scantier, obviously glandular pubescence; and from the latter very conspicuously in the much greater size and subdivision of the lamina.

4. **Psilogramme glaberrima** Maxon, sp. nov.

A weakly scandent or recumbent plant, the elongate fronds lax, probably of tardily determinate growth. Rhizome and stipe wanting in the material at hand; lamina apparently 1.5 to 2 meters long, 40 to 50 cm. broad, narrowly oblong, tripinnate-quadripinnatisect, the segments of the fourth order 1 to 3 times divaricately dichotomous; primary rachis slender (1 mm. thick), sinuous-flexuous, brownish castaneous, highly lustrous, perfectly glabrous; primary pinnae alternate (those of the same side about 12 cm. apart), slightly ascending at their point of origin but lax, apparently drooping, orbicular-deltoid, 20 to 25 cm. long, 15 to 20 cm. broad, the lustrous glabrous castaneous secondary rachis sharply flexuous; secondary pinnae 4 or 5 pairs, contiguous,

petiolate, all sharply retrorse in attachment but immediately curved upward, thus spreading or mostly ascending, the basal ones the largest, these deltoid-oblong, 9 to 11 cm. long, about 5 cm. broad, consisting of about 5 pairs of spreading, mostly inequilateral, obtuse, deltoid-oblong, deeply pinnatisect pinnules; tertiary rachises castaneous nearly throughout, narrowly foliaceo-marginate in the middle, or widely so toward the apex of the secondary pinnae; segments of the larger pinnules mostly once or twice dichotomous, the divisions divaricate, mostly simple, 2 to 5 mm. long, 1.5 to 2 mm. broad, slightly broader than the widely foliaceous rachises of the pinnules; veins solitary, evident, very slender, brownish, extending to a very narrow but deep sinus in the rounded apex of the lobe; sporangia dark brown, very numerous, those of two (rarely more) adjacent lobes joined at the base. Leaf tissue membrano-papyraceous, grayish green, fragile; hairs wholly lacking throughout, even among the sporangia.

Type in the U. S. National Herbarium, no. 827510, collected in the forests of La Palma, Costa Rica, altitude 1,459 meters, September 4, 1898, by A. Tonduz (*no. 12531*). Collected also at the same place by Brade (March 17, 1908) and by the writer (*no. 398*, May, 1906), these specimens smaller than the type collection but otherwise identical. A specimen collected by Wright at Omotepec, Nicaragua, while upon the North Pacific Exploring Expedition, is certainly the same.

Psilogramme glaberrima apparently lacks any very near relatives. In several respects it somewhat resembles *P. Orbignyana;* namely, in habit, in its flexuous secondary rachises, and in the position and curvature of its secondary pinnae, these arising retrorsely but being immediately curved and directed forward. The resemblance ends here, however, *P. Orbignyana* having numerous veinlets to the ultimate segments.

5. **Psilogramme villosula** Maxon, sp. nov.

Rhizome wanting; fronds suberect, apparently 40 to 60 cm. long; stipe incomplete, 2 to 2.5 mm. in diameter, woody, dark castaneous, sublustrous, glabrescent; lamina oblong, apparently 30 to 40 cm. long, 12 to 25 cm. broad, tripinnate or almost quadripinnate, the pinnules further divided; primary rachis similar to the stipe, subpersistently short-villose with a thin covering of short multicellular yellowish flattish hairs; primary pinnae alternate, arising at an angle of about 45°, then recurved, deltoid-oblong, acute, 8 to 15 cm. long, the secondary rachis subflexuous,

densely short-villose; secondary pinnae approximate or mostly apart, short-petiolate, deltoid-oblong, the basal ones reflexed, up to 4.5 cm. long, the others spreading; pinnules 4 or 5 pairs, spreading or slightly reflexed, rounded-triangular or narrowly subovate in outline, the larger ones cut to the narrowly marginate costa, with about 2 pairs of deeply cleft dichotomo-flabellate segments, the ultimate divisions 1 to 1.5 mm. long and about 1 mm. broad, their tips narrowly emarginate to the slender brownish vein; leaf tissue delicately herbaceous, together with the rachises and costae densely short-villose beneath, more sparsely so above, the hairs similar to those of the primary rachis or a little longer and stiffer; sporangia very numerous, usually borne throughout the veins of the segments and almost wholly covering the leaf surface, with numerous hairs intermixed.

Type in the U. S. National Herbarium, no. 471992, collected upon the Cerro de las Vueltas, Costa Rica, altitude 3,000 meters, January, 1897, by H. Pittier (*no. 10502*). A second sheet of this collection contains two laminae which are smaller but otherwise identical.

This, which is a very distinct species, is founded upon one of the two members cited by Christ* as representing *Gymnogramme Warscewiczii;* but it agrees not at all either with Mettenius's excellent description or with Karsten's later illustration. The second specimen cited by Christ (El Páramo, région du General, *Pittier 10452*) is probably still another species.

6. **Psilogramme haematodes** (Christ) Maxon.

Gymnogramma haematodes Christ, Bull. Herb. Boiss. II. 4: 1097. 1904.

TYPE LOCALITY: Summit of Volcán de Poás, Costa Rica, altitude 2,644 meters (*Tonduz 10713*).

DISTRIBUTION: Upper slopes and summits of the volcanoes Poás, Barba, Irazú, and Turrialba, Costa Rica, altitude 2,400 to 2,644 meters.

This species, well described by Christ, is exceedingly well marked by its minute, short, slightly pubescent, close-set ultimate segments. It can hardly be confused with any North American species, except possibly the plant here listed as *P. refracta*.

COSTA RICA: Summit of Volcán de Poás, alt. 2,644 meters,

* Bull. Herb. Boiss. II. 4: 1098. 1904.

Tonduz 10713. Volcán de Irazú, alt. 2,400 meters, *J. D. Smith 4999*. Forêts du Barba, *Pittier 1936*. Volcán de Turrialba, alt. 2,500 meters, *Alfaro 52*.

7. **Psilogramme refracta** (Kunze) Maxon.

Gymnogramma refracta Kunze; Klotzsch, Linnaea **20**: 410. 1847.

Anogramma refracta Fée, Gen. Fil. 184. 1852.

TYPE LOCALITY: Sierra Nevada, Colombia (*Moritz 359*).

DISTRIBUTION: Colombia and Costa Rica, ascending to 2,300 meters.

ILLUSTRATION: Fée, op. cit. *pl. 19. A. f. 2* (as *A. refracta*).

The present species is here determined solely from the original description and the small detailed figures by Fée. Without an examination of the Moritz type specimen it cannot be shown positively that Kuhn erred in referring this form to *P. flexuosa*, yet from the data at hand this seems almost certain. In any event, the Costa Rican plant mentioned below is not referable to *P. flexuosa*. Of published species it seems to agree only with the South American *P. refracta;* and if it is not really of that species it must subsequently be described as new. Its distinctive characters are indicated in the key.

COSTA RICA: Volcán de Poás, province of Alajuela, alt. 2,300 meters, March, 1896, *J. D. Smith 6931* (3 sheets).

8. PSILOGRAMME PORTORICENSIS Maxon, Contr. U. S. Nat. Herb. **17**: 412. 1914.

TYPE LOCALITY: Extreme summit of El Yunque, Porto Rico, altitude 1,110 meters.

DISTRIBUTION: Known only from the type collection (*Hioram 348*).

ILLUSTRATION: Contr. U. S. Nat. Herb. **17**: *pl. 15*.

One of the smallest species of the genus, and the only North American member of the group in which the veinlets do not extend to emarginate apices of the teeth. It has previously been compared with *P. hispidula* (Klotzsch) Kuhn, which is probably its nearest relative.

EXCLUDED OR DOUBTFUL SPECIES

PSILOGRAMME DOMINGENSIS (Baker) Underw. Bull. Torrey Club **29**: 628. 1902.

Gymnogramma domingensis Baker, Ann. Bot. **5**: 485. 1891.

TYPE LOCALITY: Alto Causal, Santo Domingo, altitude about 2,100 meters.

DISTRIBUTION: Known apparently only from the type collection.

It is impossible to determine from description whether this species, transferred to *Psilogramme* by Underwood, properly belongs to that genus. Not only is the description incomplete, but the rhizome is said to be wanting in the type specimen.

PSILOGRAMME SCHIZOPHYLLA (Baker) Underw. Bull. Torrey Club **29**: 629. 1902.

Gymnogramme schizophylla Baker, Jour. Bot. **15**: 266. 1877.

Anogramma schizophylla Diels in Engl. & Prantl, Pflanzenfam. 1^4: 258. 1899.

TYPE LOCALITY: Old England, Jamaica (*Miss Taylor*).

DISTRIBUTION: Several localities in the Blue Mountains, Jamaica, altitude 1,200 to 1,500 meters; reported also from Cuba.

ILLUSTRATION: Hook. Icon. Pl. *pl. 1682* (as *Gymnogramme schizophylla*).

This is a peculiar species whose proper disposition is doubtful. From its broad deltoid scales it is assuredly no member of *Psilogramme*, and its reference to *Anogramma* by Diels is scarcely more satisfactory. Of recognized genera it is nearest to *Pityrogramma* (*Ceropteris*) and may perhaps belong to that.

INDEX TO AMERICAN BOTANICAL LITERATURE
1910–1915

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Antennaria ampla sp. nov.

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Achlya paradoxa and *Pythiopsis Humphreyana*, spp. nov.

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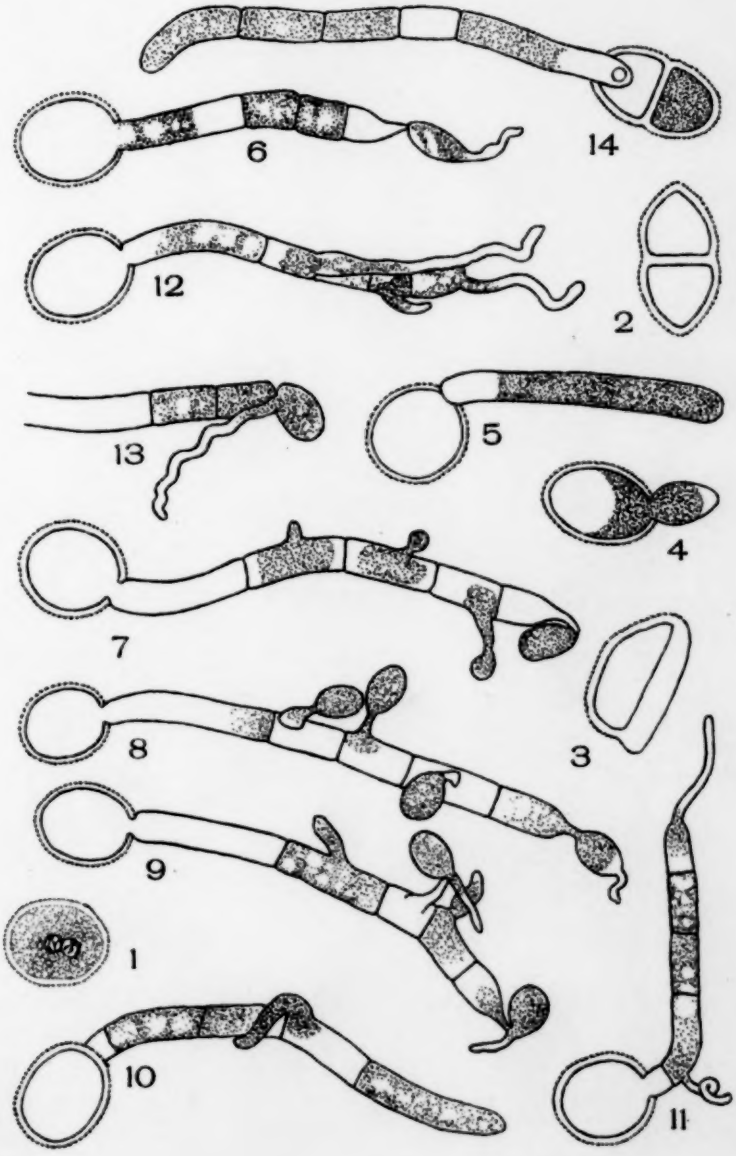
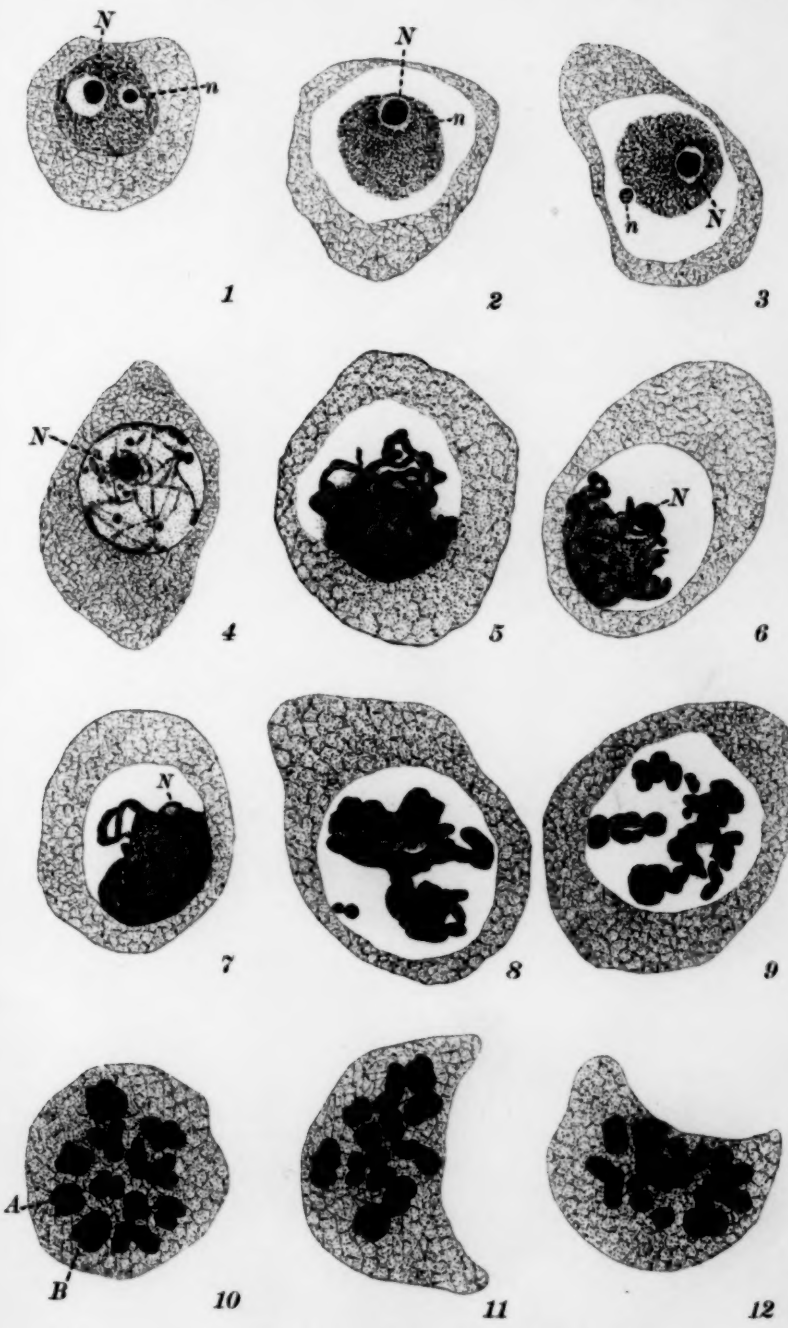


ENDOPHYLLUM TUBERCULATUM (ELLIS & KELLERM) ARTHUR & FROMME



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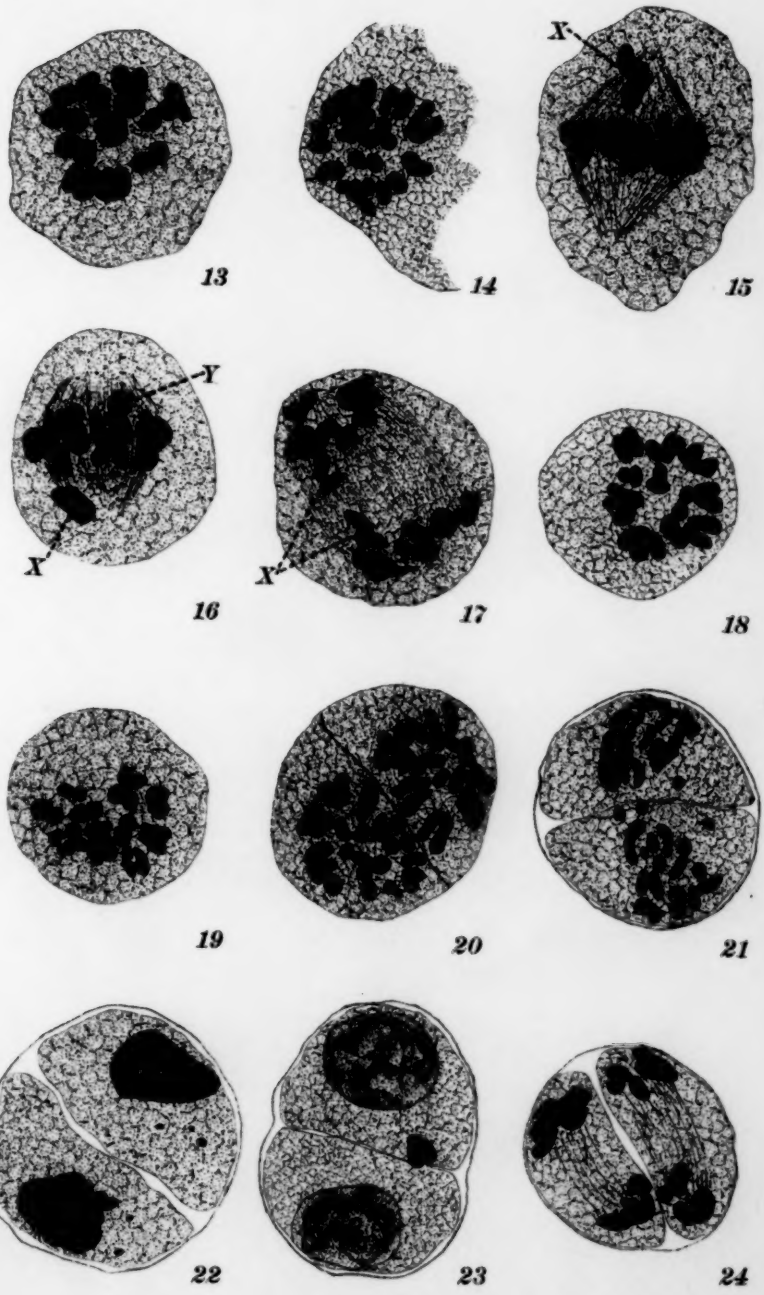

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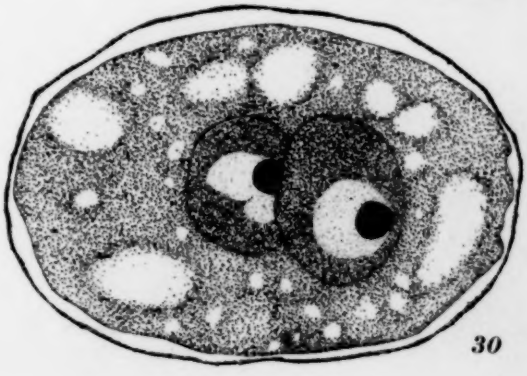

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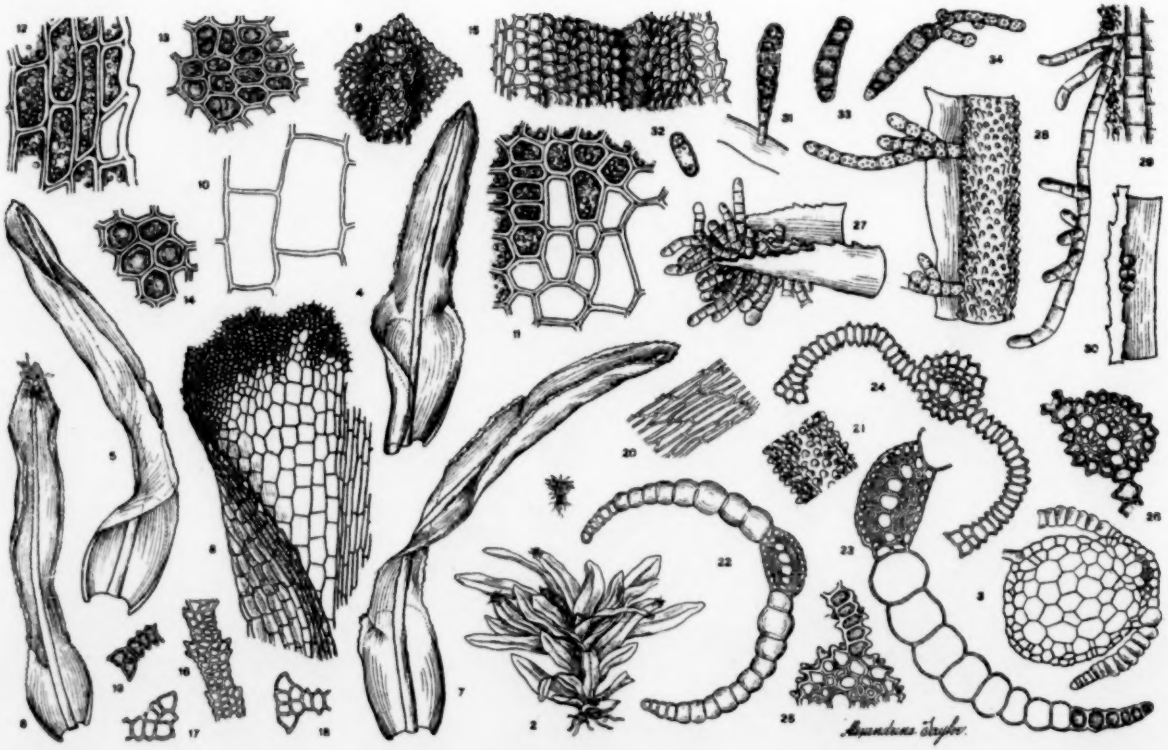
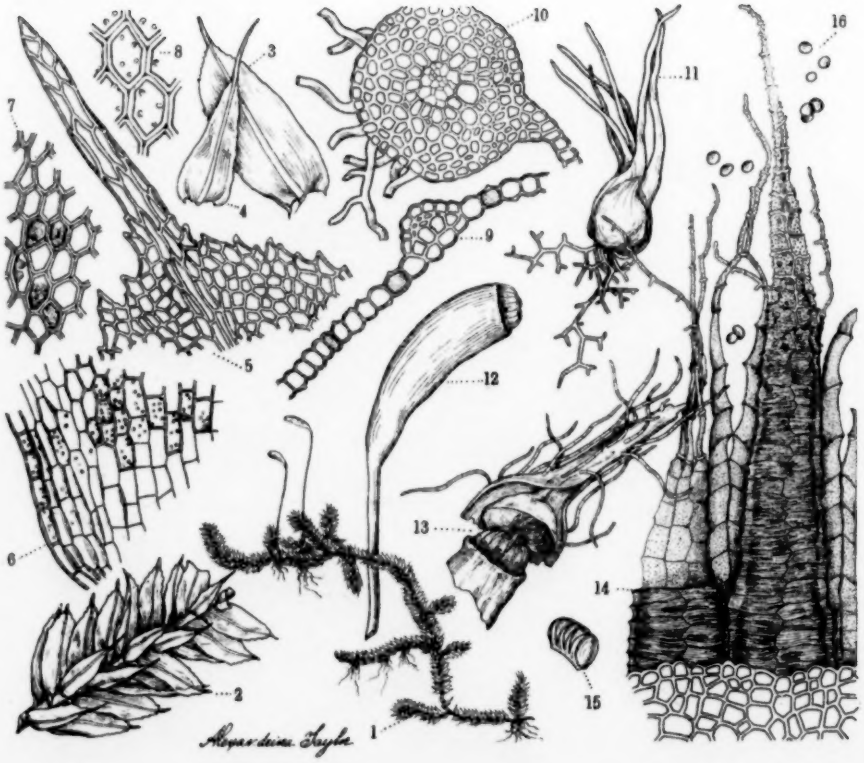


SYRRHOPODON FLORIDANUS SULL.

HELIOTYPE CO., BOSTON.



RHACOPILUM TOMENTOSUM (SW.) BRID.

HELIOTYPE CO., BOSTON.

CYANEA LARRISONII ROCK